DOCUMENT RESUME

ED 127 834 FL 008 002

AUTHOR Rogers, Sinclair; Wheeler, T. J.
TITLE Some Factors in Problem Solving: The Name of the Concept, Specific Instructions, and the Ability to Verbalise.
PUB DATE [75]
NOTE 19p.; To appear in "Contemporary Educational Psychology," 1977

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Behavior Patterns; Behavior Theories; *Child Language; *Cognitive Development; Cognitive Processes; *Concept Formation; Language Research; *Problem Solving; Psycholinguistics; Thought Processes; *Verbal Communication

ABSTRACT

Three extrinsic factors were manipulated in a problem-solving task performed by 80 ten-year-old children of I Q 90-110. The factors were: the presence or absence of the name of the concept given in feedback, specific instructions, and whether the child was allowed to verbalize. The task was a modification of Vygotsky's experiment on concept formation using concrete material. The performance criteria were: time taken to solution, number of moves, and amount of verbalization. The presence of the name of the concept given in feedback speeded the time to solution and reduced the number of moves required. Specific instruction speeded the solution but did not reduce the number of moves, whereas verbalization reduced the number of moves but increased the time of solution. (Author)

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To appear in Contemporary Educational Psychology, 1977

ED127834

"Some factors in problem-solving: the name of the concept, specific instructions, and the ability to verbalise'.

Sinclair Rogers
School of Behavioural Sciences
Ulster Polytechnic
Northern Ireland

T J Wheeler
Department of Communication Studies
Sheffield Polytechnic
England

Abstract

Three extrinsic factors were manipulated in a problem solving task performed by 80 ten year old children of I Q 90 - 110. The factors were: the presence, or absence of the name of the concept given in feedback, specific instructions, and whether the child was allowed to verbalise. The task was a modification of Vygotsky's experiment on concept formation using concrete material. The performance criteria were: time taken to solution, number of moves, and amount of verbalisation. The presence of the name of the concept given in feedback speeded the time to solution and reduced the number of moves required. Specific instruction speeded the solution but did not reduce the number of moves; whereas verbalisation reduced the number of moves but increased the time of solution.

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Introduction

Previous experiments in problem solving (reported in Simon and Newell 1971, Bourne et al 1971) have examined a number of independent linguistic variables such as spontaneous verbalisation and the amount and nature of verbal instructions. Little research has been done manipulating the presence of the name of the concept given in feedback to the subject as he is in the process of solving the problem. Previous research has also concentrated mainly on the time taken to solve the problem as being the most important and meaningful performance criterion. The evidence concerning the effects of verbalisation is unclear and, at times, contradictory; for example, Gagné and Smith (1962) found that verbalisation did not facilitate problem solving when time to completion was the criterion, but it did ensure a far greater accuracy.

However, this last feature may more likely be a function of the increased time to solution. Marks (1951) found a high correlation (.83) between performance and verbalisation. Klein (1963) has shown that non-forced verbalisation or 'soliliquising' of young children left alone with a problem solving task had different functions: either as an indication of a regulatory mechanism or as an indication of different emotional states. Beaudichon and Melot (1971, 1970) consider that, depending on the type of function that the children's verbalisation is forced by the experimenters to carry, it is possible to expect marginal facilitation or impairment in solving the problem against time. Haslerud and Meyers (1958) cite a study by Hendrix (1947) which suggested the superiority for transfer of 'not-verbalising' versus 'verbalising' by subjects themselves in solving mathematical problems. Rosenbaum (1967) found that the performance in a maze problem solving task was impaired by forced verbalisation. Bruce(1973) suggests that much verbalisation impairs problem solving (mainly measured in time taken) because it is largely

irrelevant to the task confronting the subject. Furthermore, some of the inconsistencies about the role of verbalisation in problem solving tasks are due in part to the inadequate consideration given to the task variables.

The evidence concerning the effects of specific instructions is confusing; for example, Ewart and Lambert (1932) found a large difference between the performance of groups who were given a verbally stated principle of solution in the instructions, and groups who were not. Corman (1957) failed to find any significant difference in performance among groups given various amounts of verbal instructions. This result is broadly supported by the findings of Gagné and Smith (1962) Alternatively, Haslerud and Meyers (1958) actually found an experimental situation where verbally stated principles of the solution of cryptograms when given in the instructions, impaired the solution of new cryptograms.

Marks (1951) found that no significant effects were produced with subjects who were given a typed list of concept information. Katona (1940) has shown that verbal instructions are much less effective than showing the subject by example.

Mandler (1967), Norman (1970), and Posner (1969) can be seen as offering a reconciliation of these apparent inconsistencies of the effects of different amounts of instructions. It is that these inconsistencies may be due to the subject being able to remember and/or process certain types of instructions (or principles) more easily than others. In order that the subject be able to utilise the concept information given him by the experimenter, he must have processed it in some way. It has been debated by Legrenzi (1971) for example, whether the subject utilises more effectively his own discovered concepts or whether he benefits (in terms of speed of solution of the problem) from being given information about the concept by the experimenter. Some researchers (Dunker 1945,

Wertheimer 1956) have thought that the main purpose of specific instructions represents a 'restructuring of the field', a 'reorganising of the task', or 'seeing the problem in a new way'.

Previous experiments (Wason 1968, 1969) have established that it is very difficult to examine the development of a subject's understanding and use of a specified abstract concept. Disjunctive concepts are more often used than conditional concepts (Wason and Johnson-Laird 1972), so that the subject tends to use incomplete concepts, or concepts which are not entirely understood, as steps towards a final solution. Wason and Shapiro (1971) have shown that great difficulties with problem solving tasks exist when abstract and not concrete material is used. It was therefore decided to choose a problem in which concrete material was used.

Given the at times contradictory evidence concerning the effects of the three experimental factors that were manipulated the following predictions formed the basis of the investigation reported here:

1. The presence of the name of the concept given in feedback to the subject as he solved the problem would speed the time to solution and reduce the number of moves for two reasons. The child would be given a name around which to conceptualise; and at the same time as the child solved one group, he would be able to start grouping other groups according to their name.
2. The presence of specific instructions would be of no significant advantage because the subject would not be able to use concepts given to him externally so effectively as those he was able to derive for himself.
3. The ability to verbalise would impair the problem solving because it was likely to be an irrelevant parallel process (Furth 1975).

The Present Experiment

The present experiment is a modification of a classic experiment in concept formation performed by Vygotsky in 1939 (reported in Vygotsky 1962). The purpose of Vygotsky's investigation was to see whether the relational concepts of varying combinations of height and cross-section which together were not normally coded in Russian, could be discovered with the aid of the name of the concept being given in feedback. Vygotsky did not compare the effects of the presence versus the absence of the name of the concept. The children in Vygotsky's experiment were able to use two 'ideal strategies': 'focusing' and 'scanning' in the solution of the problem set them (Boyle 1971, pp 107 - 109).

The purpose of the present experiment was to manipulate the following factors: the presence of the name of the concept given in feedback, specific verbal instructions, whether the child was allowed to verbalise; and the measures of performance were; time taken to solution, the number of moves to solution, and the amount of verbalisation when allowed.

Experimental Design

A three-factor independent subjects design was employed manipulating three experimental parameters:

1. whether the name of the concept was given by a single word in feedback to the child in the process of the task, (A../B..);
2. whether the two concepts defining each group viz: height and cross-section were specifically referred to in the instructions, (.1./.2.);
3. whether external verbalisation by the child was permitted. In this context, verbalisation was taken to be a free use of language with no instructions to 'talk out' the solution of the problem, (..A/..B).

This gave the following eight experimental conditions:

Ref No	The Name of Concept in Feedback	Specific Instruction	Verbalisation
A1A	absent	absent	absent
A1B	absent	absent	present
A2A	absent	present	absent
A2B	absent	present	present
B1A	present	absent	absent
B1B	present	absent	present
B2A	present	present	absent
B2B	present	present	present

As there was practically no sub-vocal speech as discussed by Flavell, Beach and Chinsky (1966), verbalisation in this experiment was defined as comprehensible speech involving syntax and lexis; in this way, unstructured noises were excluded from the time measurement of verbalisation.

Subjects

The subjects were 80 children (42 male and 38 female) at junior schools aged between ten years one month and ten years eleven months. The choice of the age-group of the children was determined by the findings of Saltz et al (1972) who suggested that the development of natural language concepts had been largely achieved by ten to eleven years of age. Their I Qs were in the range 90 - 110 obtained on a Moray House Non-Verbal test. The children were assigned randomly to eight experimental groups. Each child volunteered to take part in the study, and was questioned to ascertain that he or she had had no previous acquaintance with the problem. No child was, in fact, excluded on those grounds.

Apparatus

A set of sixteen modified Vygotsky blocks; four groups of four of TUR, CEV, BEK, MEL. UHER 2000 portable tape recorder - to record the duration of the external verbalisation. Stopwatch and comptometer.

Task

The blocks had to be grouped according to the following four concepts:

TUR	tall	+	Large surface area
CEV	short	+	Small surface area
BEK	short	+	Large surface area
MEL	tall	+	Small surface area

The following modifications to Vygotsky's 1939 experiment were made:

1. the number of blocks was reduced to sixteen from Vygotsky's twenty-two in order to make the task simpler.
2. the blocks were all of the same colour thus making the task simpler and removing a source of possible variation.
3. the words used to code each group were TUR CEV BEK and MEL. These are alterations of the original nonsense words selected by Vygotsky because some of his choices were thought to have some significance to English children, such as BIK or LAG.

Procedure

Each child was given the problem separately in a quiet room. As the child sat at a table he was shown the sixteen blocks in a random arrangement on a flat table before him. The child was asked to choose one block at random from all those in front of him. From then on the instructions were according to which experimental group the child was in:

Group A1A "Here are lots of blocks. Will you find all the blocks that belong to the group of the one you have there? You must not speak as you are doing this, or ask me any questions. You may start when I say now."

Group A1B The same as for Group A1A, except that for the second sentence the following was substituted: "You may talk while you are doing this, but you must not ask me any questions."

Group A2A "Here are lots of blocks of different shapes and sizes. Will you find all the blocks that belong to the one group of the one you have there? Remember, tall blocks only go with tall blocks and big blocks only go with big blocks. You must not speak as you are doing this, or ask me any questions. You may start when I say now."

Group A2B The same as for group A2A, except that for the third sentence the following was substituted: "You may talk while you are doing this, but you must not ask me any questions."

Groups B1A, B1B, B2A, and B2B followed the same schemata except that after the first sentence in each case the child was shown the underside of the block he had selected and told: "This is a CEV (or whatever)."

The child was told "now" and timing was started. Every time the child moved a block into a group this was scored on a comptometer.

If the child was in groups (B..) where the names of the concepts were provided in the feedback, each time the child made a wrong grouping he was corrected in the following way as the interviewer turned the block wrongly selected upside down to show the child the word on the base: "No, that's wrong. This is a PUK and you are looking for a CEV."

If the child was in groups (A..) without the name of the concept given in feedback, each time the child made a wrong grouping he was merely told: "No, that's wrong. They are not in the same group."

In each case, when the child had selected the other three blocks of the group, he was asked to choose another single block and asked to find the rest of the blocks in that group.

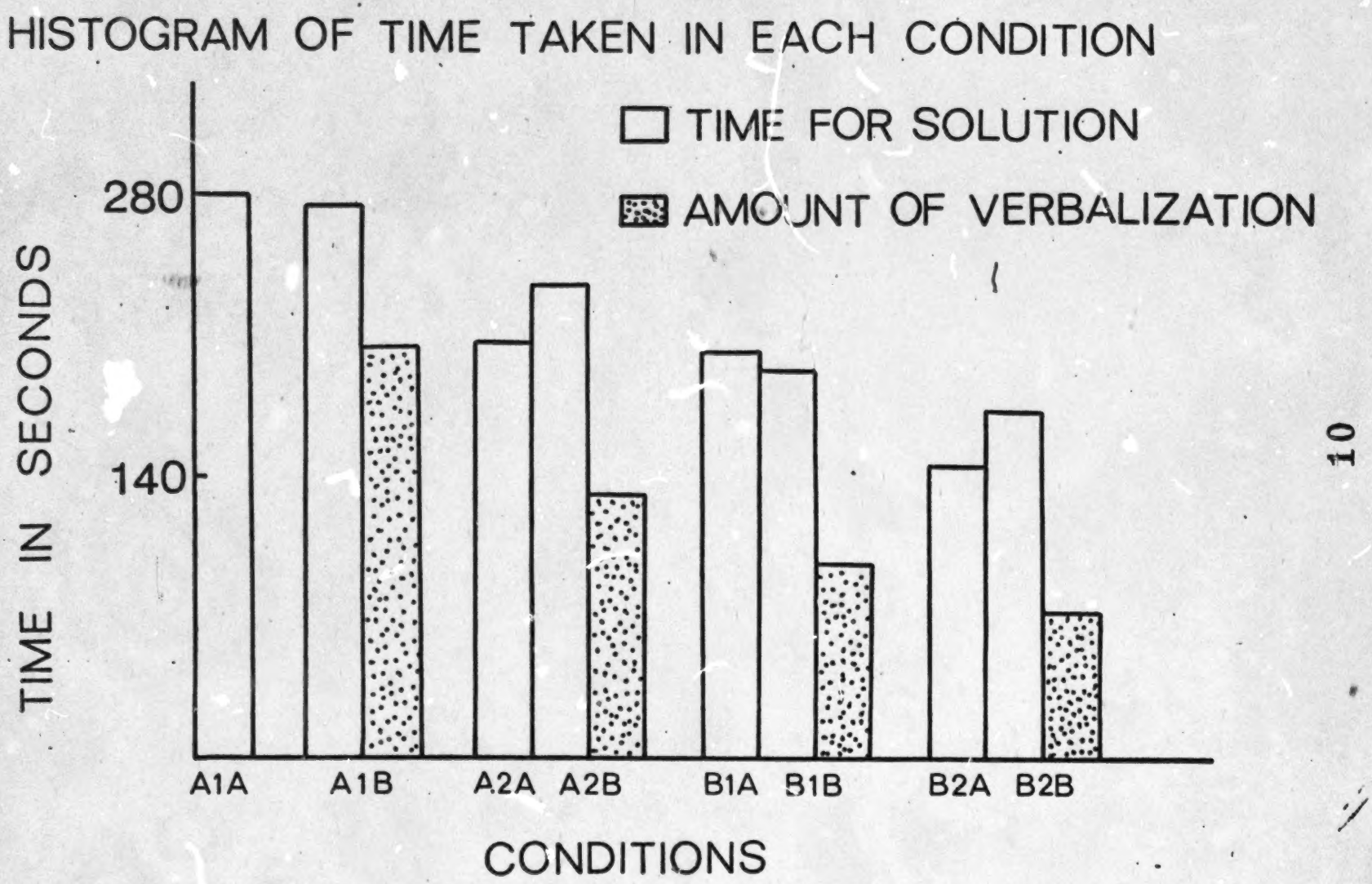
HISTOGRAM OF TIME TAKEN IN EACH CONDITION
TIME FOR SOLUTION
AMOUNT OF VERBALIZATION
280
140
TIME IN SECONDS
A1A
A1B
A2A
A2B
B1A
B1B
B2A
B2B
CONDITIONS

FIGURE 1

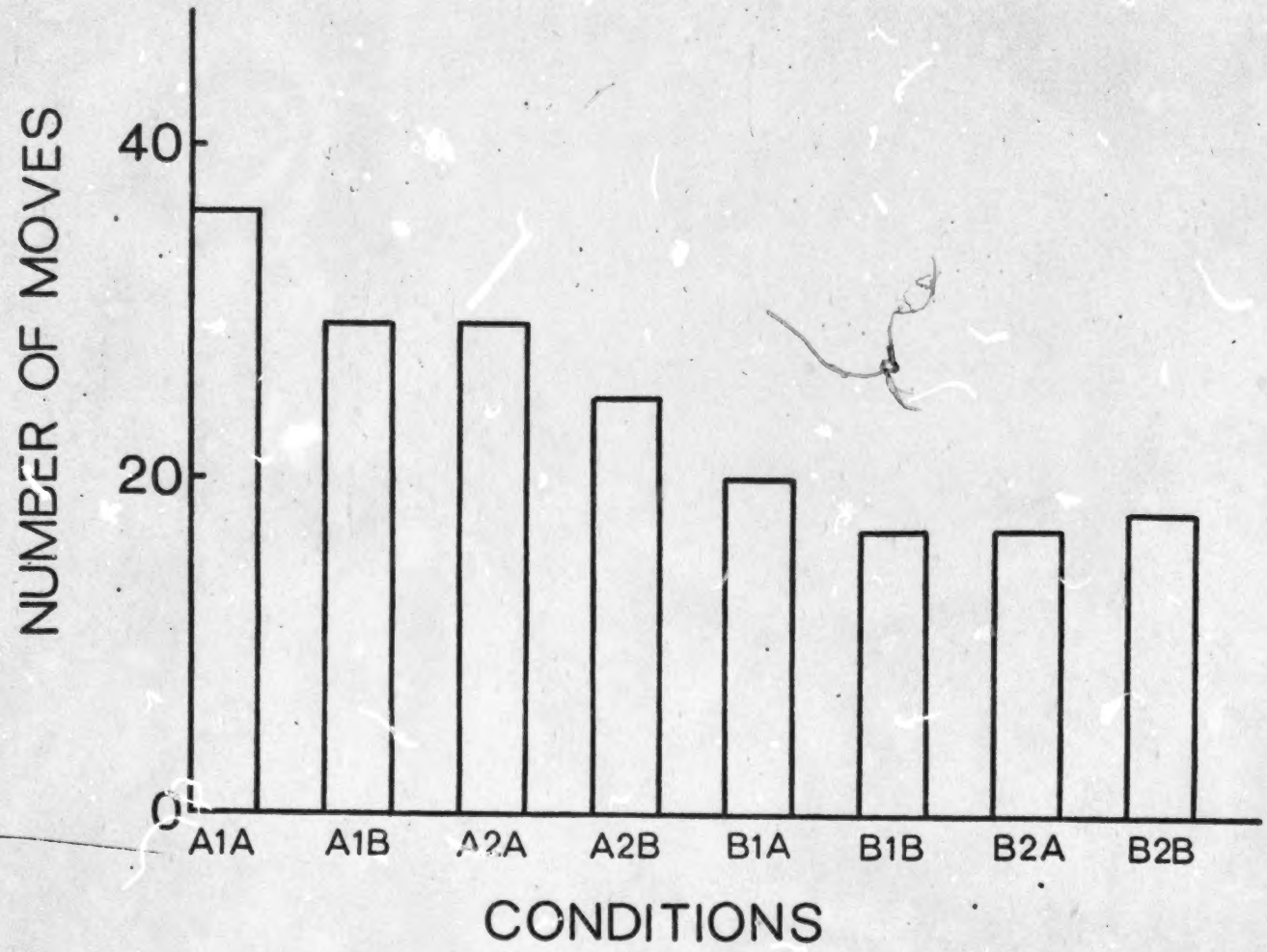
HISTOGRAM OF MOVES TAKEN IN EACH CONDITION
NUMBER OF MOVES
40
20
0
A1A
A1B
A2A
A2B
B1A
B1B
B2A
B2B
CONDITIONS

FIGURE 11

When the child had successfully grouped the sixteen blocks, the timing was stopped. For children where verbalisation was permitted, a tape recorder was used to record the amount of verbalisation. This was timed later. However, the tape recorder was present at all 80 interviews.

Results

(Insert histograms, figures I and II)

A three Factor Analysis of Variance yielded the following results:

The presence of the name of the concept given in feedback was found to speed the time of solution ($F = 47.23$; $df = 1,72$; $p = .001$), reduce the number of moves ($F = 65.84$; $df = 1,72$; $p = .001$), and reduce the amount of verbalisation as a proportion of the total time taken ($F = 37.94$; $df = 1,36$; $p = .001$).

The presence of specific instructions reduced the time taken ($F = 41.79$; $df = 1,72$; $p = .001$), but did not reduce the number of moves ($F = 3.46$; $df = 1,72$; $p = NS$): it did however reduce the amount of verbalisation as a proportion of the total time taken ($F = 13.78$; $df = 1,36$; $p = .001$).

The ability to verbalise produced a significant increase in the time taken to solution ($F = 6.21$; $df = 1,72$; $p = .05$), but reduced the number of moves ($F = 5.35$; $df = 1,72$; $p = .05$).

There was no significant variation within groups for time ($F = .83$; $df = 7,72$; $p = NS$), for moves ($F = .72$; $df = 7,72$; $p = NS$) or proportion of verbalisation ($f = 2.84$; $df = 3,36$; $p = NS$).

There were no significant interaction effects.

Discussion

Most of the performance measures were reduced as increasing presence of the experimental variables was introduced. There are, however, some exceptions to these general findings: both A2B and B2B take longer than A2A and B2A to solve. Both these differences are shown to be significantly

different at p = .05. It is contended that in these cases the addition of verbalisation tends to act as a "regulatory mechanism" as Klein (1963) suggests. These exceptions are compatible with the analysis of variance results that suggest that there is an increase in the time taken to solve the problem when verbalisation is permitted. This result is compatible with the findings of Gagné & Smith (1962). In comparing the effect of verbalisation, the number of moves taken to reach a correct solution is found to increase from condition B2A to B2B. This is not a significant difference and can be accounted for by possible sample variation.

The presence of the name of the concept given in feedback produces a significant reduction in the time taken and in the number of moves required for solution, as well as a reduction in the amount of verbalisation. This can be explained by considering the situation when the child is given the name of the concept and when he is not. In the former the child is able to use both "scanning" and "focussing strategies", whereas in the latter he is only able to use a "scanning strategy" (Boyle 1971). Furthermore, by being given the name of the concept in feedback the child is able to carry out simultaneously the matching of at least one more group, as he picks up one block after another, and is given the concept name.

The presence of specific instructions produced no significant reduction in the number of moves taken, but did produce a significant reduction in the time taken. This is possibly because specific instructions facilitate the speed of coding of the concept information, whilst leaving the number of moves required unaffected. This appears to clear up some of the confusion between the work of such people as Ewart and Lambert (1932), Corman (1957) and Haslerud and Meyers (1958) who disagree about the effect of verbal instructions on problem solving as they used different performance measures (either time or moves taken).

The facility of children to verbalise produced a significant drop in the number of moves required for solution, but produced a significant increase in the time taken to solve the problem. In this situation the child is thought to be "talking out the problem" by making hypothetical "trial and error" moves without actually making them. This was very noticeable in the experiments when children often hesitated with their hand above a block and discussed with themselves whether or not they should pick it up. Often they did not, but rather picked up another block.

When verbalisation is permitted, there is a significant reduction in the actual amount of verbalisation between conditions of the presence of the name of the concept given in information or the absence, and conditions of the presence of specific instructions. This can be explained by considering that the presence of verbal information in the specific instructions appears to make some of the child's verbalisation unnecessary.

Table 1

Correlations between the number of moves and time taken for each child

Condition	Correlation	P Value
A1A	+.87	.001
A1B	0	N.Sig.
A2A	+.63	.01
A2B	+.39	.05
B1A	+.71	.01
B1B	+.43	.05
B2A	+.53	.05
B2B	-.62	.01

The reasons for this are either that some of the child's preliminary concept formation has been done for him, or that the specificity of the instructions removes some of the possible groupings. In this respect the results are at variance with those of Legrezi (1971), who found that subjects who discovered their own rules of solution performed better than those who were given rules of solution. This difference can be reconciled because he did not employ a problem in which the name of the concept was given in feedback throughout the whole procedd of solution. The absence of any significant interactions proves that the three factors are truly independent factors and that their effect will be felt individually even when combined with the other remaining factors for time or numbers of moves for solution.

The correlation coefficients (Table 1) for the ten children within each condition yielded results consistent with the previous findings. In all the groups where verbalisation is not allowed, significantly positive correlations are obtained. This is not particularly surprising as it would be expected that the more time that a child took, the more moves he would make and vice-versa.

However, in the group where verbalisation is permitted, significant negative, zero, or insignificant positive correlations are obtained. In condition B2B there is a significant negative correlation. This can be explained by considering the fact that the child is "talking out the problem" rather than "moving out the problem". Again this is consistent with data on the presence of verbalisation.

This can be explained by assuming that the time taken is relatively independent of the number of moves made and vice-versa. These results are consistent with those from the analysis of variance for the presence of verbalisation, which shows an increase in time, and a significant reduction in the number of moves made to solution.

The results from the three analyses of variance support the notion of employing more than one performance measure, in that previously conflicting research findings can be reconciled.

The investigation has found that the presence of the name of the concept given in feedback is of importance in facilitating problem solving involving abstract concept formation. It has also been shown that specific instructions can speed the solution of the problem; and that to permit verbalisation can help to reduce the number of moves necessary in problem solving.

Acknowledgements

The authors wish to acknowledge the help given by the Audio-Visual Centre of the University of East Anglia in making the Vygotsky blocks, and the Department of Psychology of the University College of North Wales, Bangor.

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